Planning Community of Practice
Crowne Plaza Hotel
San Antonio, TX
20 May 2008

Actions for Change Theme 1: Comprehensive Systems Approach Remaining PDTs

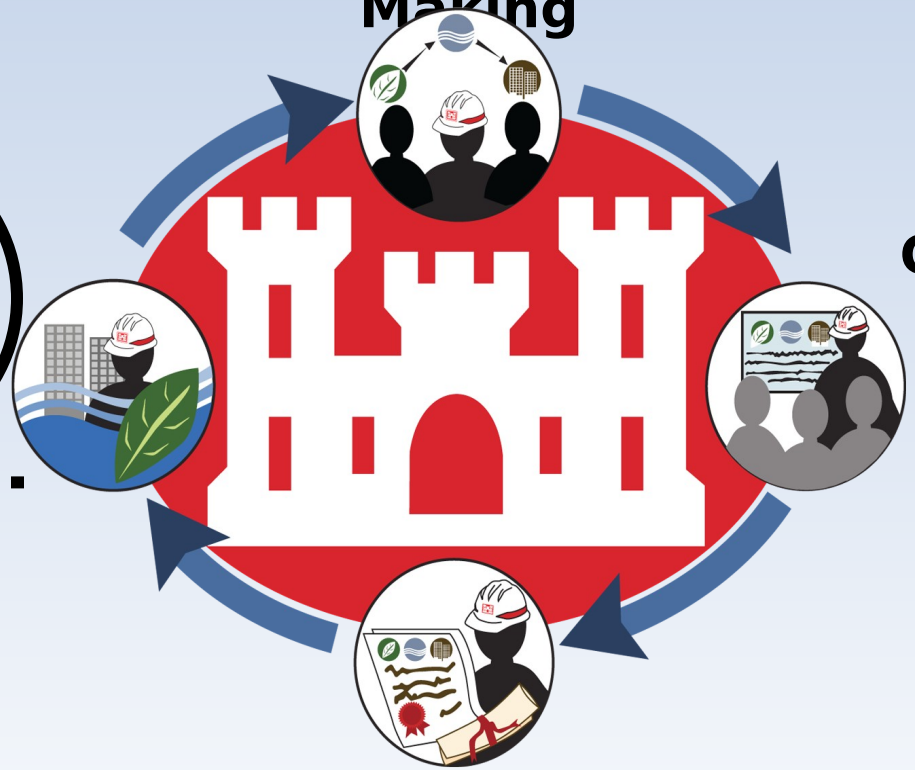
Kate White, PhD, PE
Lead, USACE Actions for Change Theme 1: Comprehensive Systems Approach
kathleen.d.white@usace.army.mil

ACTIONS for CHANGE

USACE Actions for Change

Risk Informed Decision Making

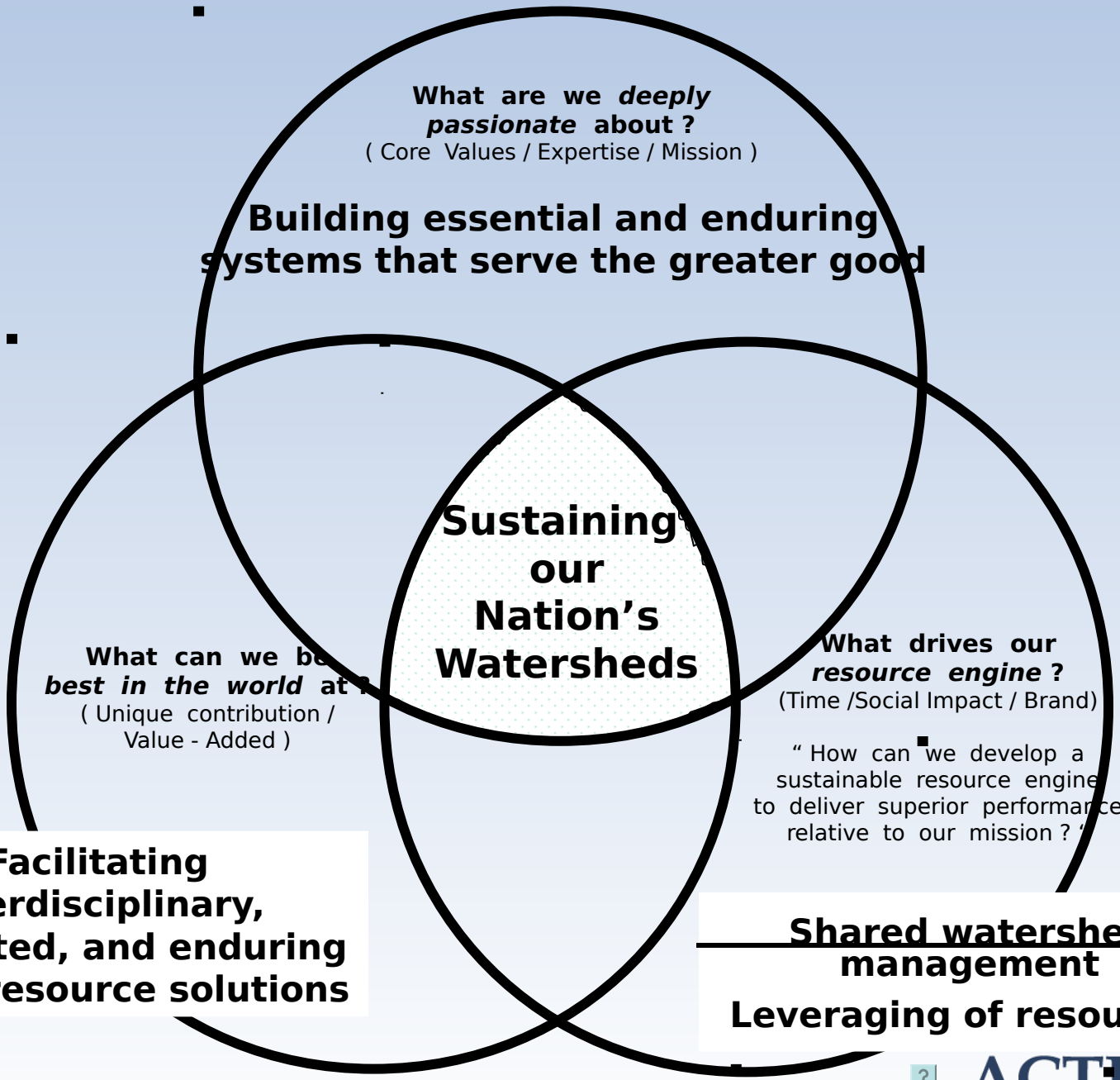
Comprehensive Systems Approach



Communication of Risk to the Public

Professional and Technical Expertise

ACTIONS for CHANGE

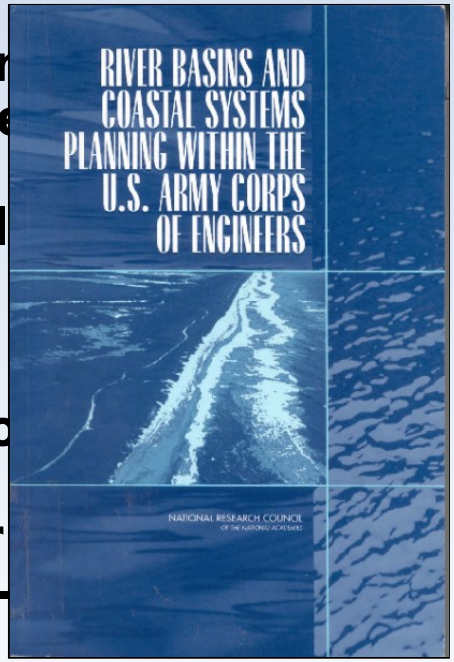

What are we *deeply passionate* about ?
(Core Values / Expertise / Mission)
Building essential and enduring systems that serve the greater good
Sustaining our Nation's Watersheds
What can we be *best in the world* at ?
(Unique contribution / Value - Added)
What drives our *resource engine* ?
(Time /Social Impact / Brand)
" How can we develop a sustainable resource engine to deliver superior performance relative to our mission ? "
Facilitating interdisciplinary, integrated, and enduring water resource solutions
Shared watershed management
Leveraging of resources

ACTIONS for CHANGE

After COL Dornstauder

AFC Comprehensive Systems Approach

- **What is a system?**
  - **A dynamic and complex whole interacting as a structured functional unit**
- **What is a comprehensive systems approach?**
  - **A multidisciplinary, multi-objective, and multi-stakeholder framework supportin "a balanced evaluation of all re issues (e.g., hydrologic, geomorphic, ecologic, social economic)" (NRC 2004, p. 19)**
- **Corps-specific context?**
  - **Shifting the focus on making decisions fro individual, isolated projects to an interdependent system, and from local or immediate solutions to regional or long- solutions, at appropriate scales of space and time**



ACTIONS for CHANGE

AFC Theme 1 PDTs

- **Vertical Control**
- **Temporal and Spatial System Changes**
- **Adaptive Management**
- **Sustainable Solutions**
- **Post-Construction System Evaluation**
- **Multipurpose System Planning and Policy**
- **Incremental Changes to USACE Systems**

ACTIONS for CHANGE

Temporal and Spatial System Changes PDT

- **Background**
  - **American Society of Civil Engineers post-Katrina review panel stressed *need to incorporate new and changing information***
  - **USACE does not currently have a flexible process (planning or design criteria) allowing for alternatives to be selected that can *adapt to anticipated changes, unanticipated changes or otherwise unexpected outcomes***
- **PDT Lead**
  - **Rolf Olsen (IWR)**

Temporal and Spatial System Changes PDT

- **Objective**
  - **Review *dynamic processes* that potentially impact USACE projects on watershed, regional or system bases**
  - **Develop guidelines and recommend policy and program changes along with supporting technologies, to address temporal and spatial changes and their impacts**
  - ***Increase confidence* in new projects and major rehabilitations through consideration of explicit adjustments due to future unforeseen impacts or other developments in design, planning, operations and maintenance**
  - ***Reduce adverse consequences* as USACE addresses changes before they become a problem**

POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1]* Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (*1*).

The stationarity assumption has long been compromised by human disturbances in river basins. Flood risk, water supply, and water quality are affected by water infrastructure, channel modifications, drainage works, and land-cover and land-use change. Two other (sometimes indistinguishable) challenges to stationarity have been externally forced, natural climate changes and low-frequency, internal variability (e.g., the Atlantic multidecadal oscillation) enhanced by the slow dynamics of the oceans and ice sheets (*2*, *3*). Planners have tools to adjust their analyses for known human disturbances within river basins, and justifiably or not, they generally have considered natural change and variability to be sufficiently small to allow stationarity-based design.

[1]U.S. Geological Survey (USGS), clo National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA. [2]USGS, Tucson, AZ 85745, USA. [3]Stockholm International Water Institute, SE 11151 Stockholm, Sweden. [4]USGS, Reston, VA 20192, USA. [5]Research Centre for Agriculture and Forest Environment, Polish Academy of Sciences, Poznań, Poland, and Potsdam Institute for Climate Impact Research, Potsdam, Germany. [6]University of Washington, Seattle, WA 98195, USA. [7]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA.

*Author for correspondence. E-mail: cmilly@usgs.gov.

An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now underway, however, we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to changing climate.

How did stationarity die? Stationarity is dead because substantial anthropogenic change of Earth's climate is altering the means and extremes of precipitation, evapotranspiration, and rates of discharge of rivers (*4*, *5*) (see figure, above). Warming augments atmospheric humidity and water transport. This increases precipitation, and possibly flood risk, where prevailing atmospheric water-vapor fluxes converge (*6*). Rising sea level induces gradually heightened risk of contamination of coastal freshwater supplies. Glacial meltwater temporarily enhances water availability, but glacier and snow-pack losses diminish natural seasonal and interannual storage (*7*).

Anthropogenic climate warming appears to be driving a poleward expansion of the subtropical dry zone (*8*), thereby reducing runoff in some regions. Together, circulatory and thermodynamic responses largely explain the picture of regional gainers and losers of sustainable freshwater availability that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have arisen from unforced variability and is consistent with modeled response to climate forcing (*15*). Paleohydrologic studies suggest that small changes in mean climate might produce large changes in extremes (*16*), although attempts to detect a recent change in global flood frequency have been equivocal (*17*, *18*). Projected changes in runoff during the multidecade lifetime of major water infrastructure projects begun now are large enough to push hydroclimate beyond the range of historical behaviors (*19*). Some regions have little infrastructure to buffer the impacts of change.

Stationarity cannot be revived. Even with aggressive mitigation, continued warming is very likely, given the residence time of atmospheric CO_2 and the thermal inertia of the Earth system (*4*, *20*).

A successor. We need to find ways to identify nonstationary probabilistic models of relevant environmental variables and to use those models to optimize water systems. The challenge is daunting. Patterns of change are complex; uncertainties are large; and the knowledge base changes rapidly.

Under the rational planning framework advanced by the Harvard Water Program (*21*, *22*), the assumption of stationarity was

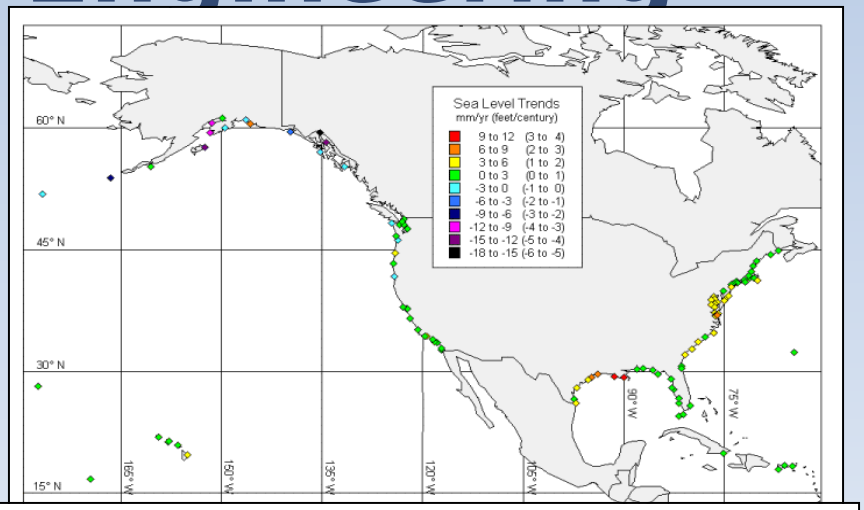
Published by AAAS

Downloaded from www.sciencemag.org on February 13, 2008

ACTIONS for CHANGE

Anticipatory Engineering

- **Types of changes that affect system reliability and risk:**
  - **Subsidence**
  - **Climate change and variability**
  - **Altered seismicity**
  - **Demographic changes and development**
  - **Land use changes and changes in rainfall-run characteristics**
  - **Channel migratio**
  - **Social/cultural changes**



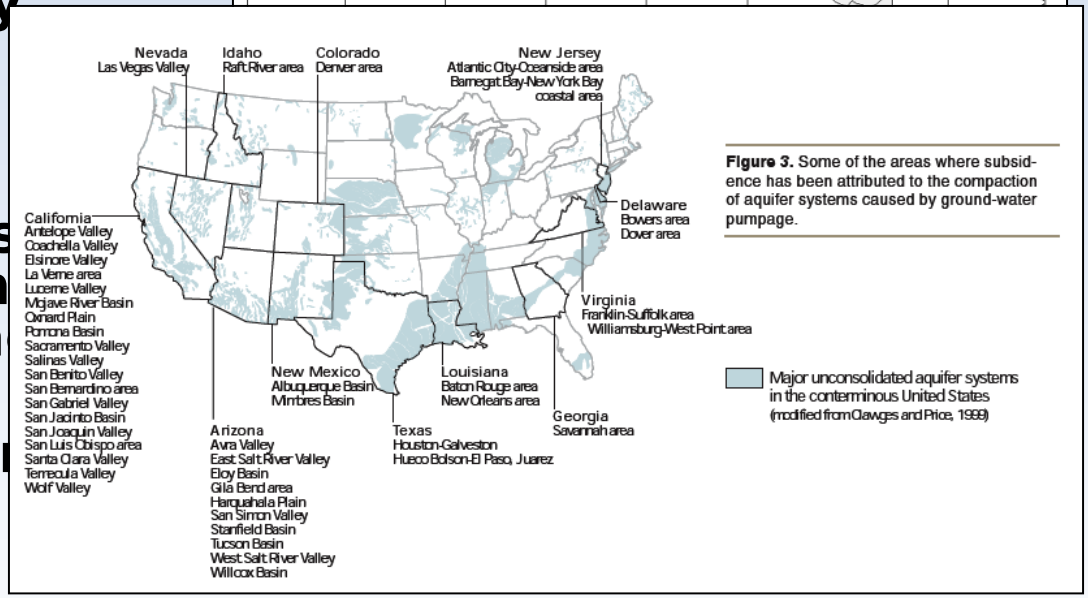


Figure 3. Some of the areas where subsidence has been attributed to the compaction of aquifer systems caused by ground-water pumpage.

ACTIONS for CHANGE

Temporal and Spatial System Changes PDT

- **Near Term PDT Activities**
  - **Sea level change planning and engineering guidance**
  - **Geospatial tool for vulnerability analysis**
    - **Initial product: USACE coastal projects and local relative sea level rise**
  - **Interagency paper on climate change and water resources**
  - **Review of USACE vulnerability to seismic events**
  - **Water management operations with climate change**
  - **Workshop on alternatives to stationarity**

ACTIONS for CHANGE

Sustainable Solutions PDT

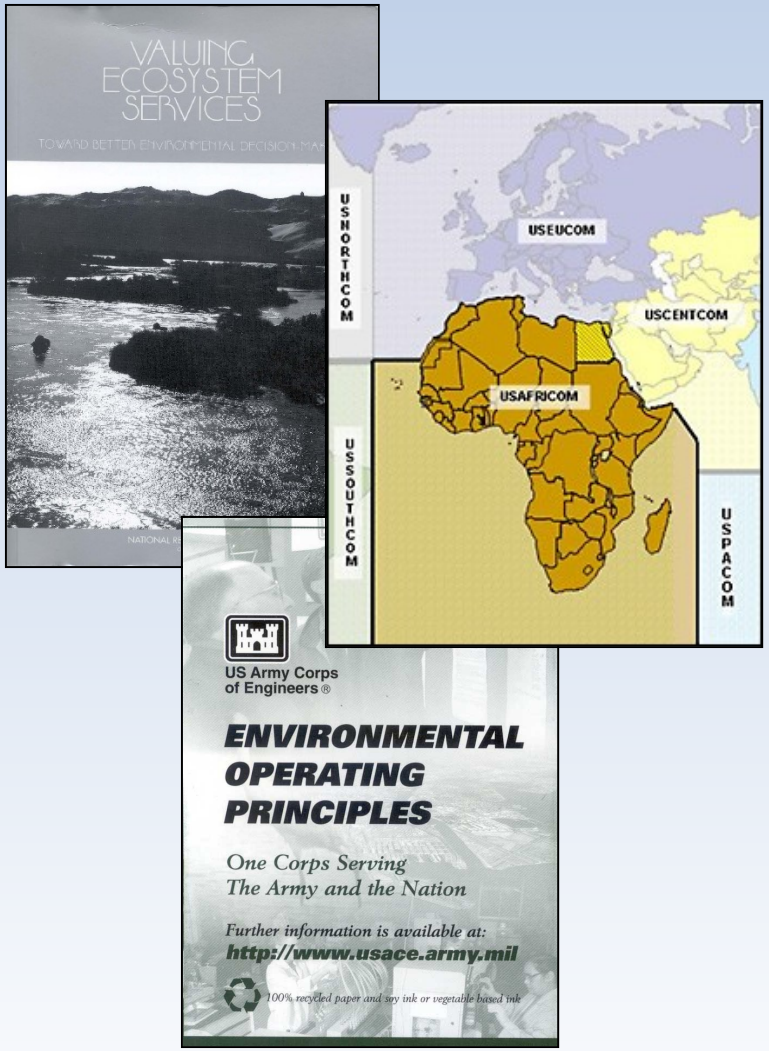
- **Background**
  - **Sustainable development is characterized as meeting the needs of the present without compromising the ability of *future generations* to meet their needs**
  - **Globally, infrastructure management programs are face increasingly *scarce resources* and heightened concern for environmental impacts**
  - **In 2003, USACE published its *Environmental Operating Principles* which promotes the application of sustainability in USACE projects**

ACTIONS for CHANGE

Sustainable Solutions PDT

- **Objective**
  - **Support system alternatives recognizing complex, changeable and *interconnected ecologic, economic, and social effects* to achieve long-term sustainability**
  - **Develop projects within the framework of the USACE Environmental Operating Principles**

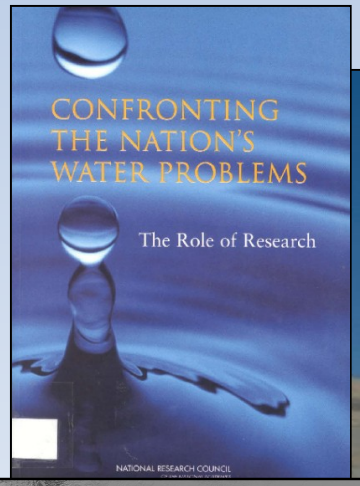
- **PDT Lead**
  - **Frank Appelfeller (LRD)**

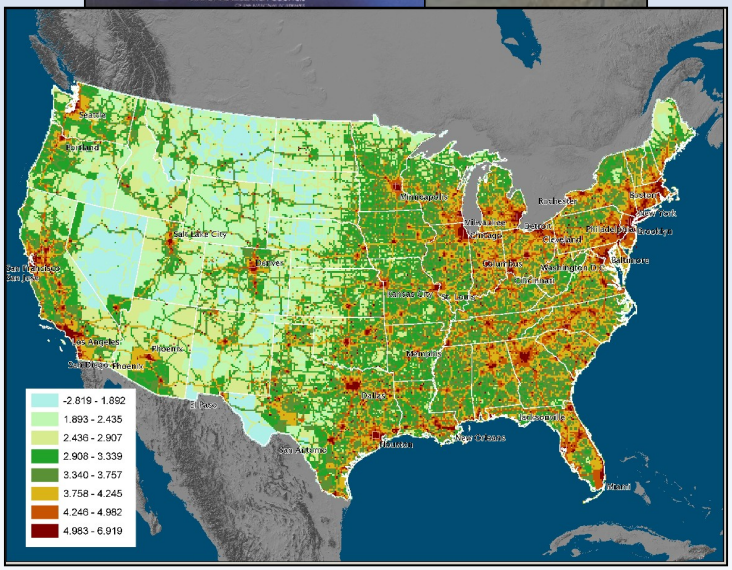


ACTIONS for CHANGE

Sustainable Solutions PDT

- **Planned products and activities**
  - **Guidance and tools to support the inclusion of sustainable solutions in USACE program and project development**
  - **Modified PMBP processes to integrate new policies and procedures into project execution**
- **Near Term PDT Activities**
  - **Conduct Sustainable Solutions Workshop**
  - **Baseline Report: Current state of practice for USACE "green" building solutions**
  - **Baseline Report: Current state of policies, methods and technologies internal and external to USACE that support the analysis of systems for long-term sustainability**





ACTIONS for CHANGE

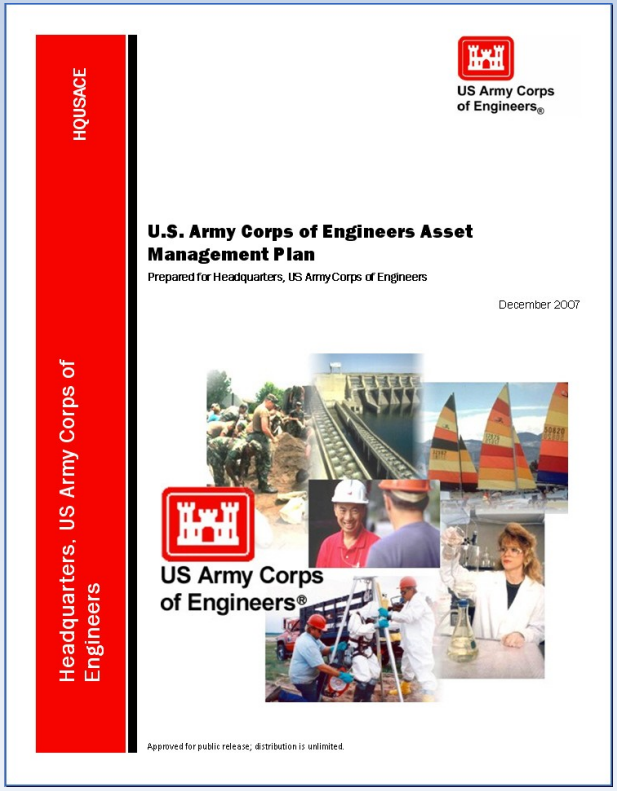
Vulcan map shows where CO2 is being emitted in the continental United States in 10-kilometer grids and combines data from sources including factories, automobiles on highways and power plants. The map offers more than 100 times the detail of previous inventories of carbon dioxide. The image displays metric tons of carbon per year per grid in a logarithmic base-10 scale. (Purdue University: Kevin Gurney).

Post-Construction System Evaluation PDT

- **Background**
  - **USACE owns and manages a *diverse and extensive portfolio of infrastructure assets* whose value ranks among the top five of all Federal agencies**
  - **USACE has a tremendous responsibility to Congress and the taxpayer to sustain this infrastructure at its highest levels of performance**
  - **As service life of this aging infrastructure is often extended beyond design life, it is imperative that a *proactive, resilient, and sustainable system wide approach to life cycle asset management* be implemented**

Post-Construction System Evaluation PDT

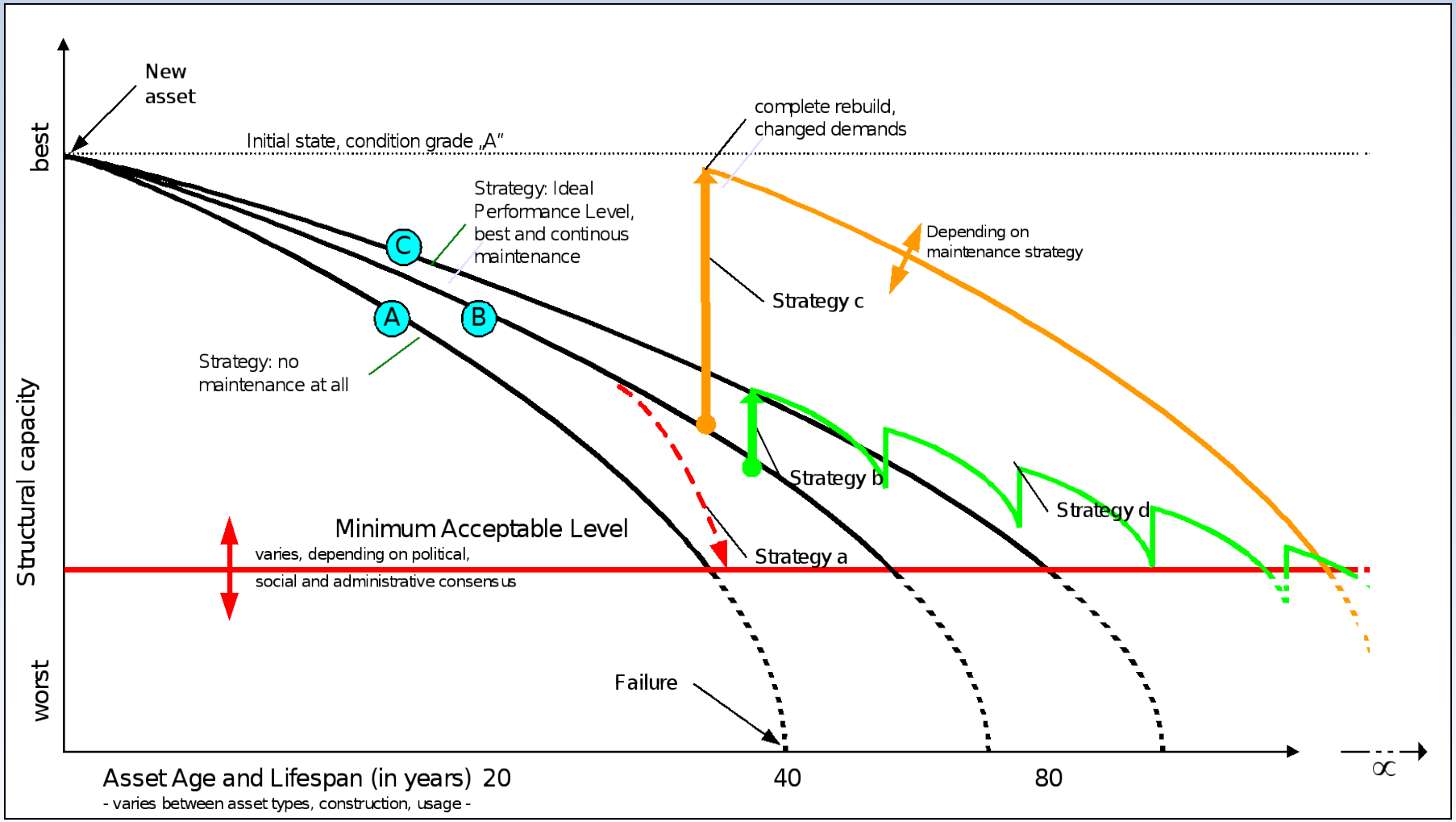
- **Objective**
  - **Enhance multi-objective decision making for post-construction evaluation of project outcomes, leveraging enhanced data collection and integrating existing management and geospatial databases***
  - **Bottom Line: all USACE business lines are users**
- **PDT Lead**
  - **Jose Sanchez (HQUSACE)**


HQUSACE
Headquarters, US Army Corps of Engineers
US Army Corps of Engineers®
U.S. Army Corps of Engineers Asset Management Plan
Prepared for Headquarters, US Army Corps of Engineers
December 2007
US Army Corps of Engineers®
Approved for public release; distribution is unlimited.

ACTIONS for CHANGE

* e.g., Asset Management, Dam Safety, Levee Safety, ORM2, and Inspection of Completed Works

Life-Cycle System Evaluation



Post-Construction System Evaluation PDT

- **Planned Products and Activities**
  - **Tool to evaluate incremental changes affecting infrastructure on a system basis**
  - **Tool to visualize the *cumulative impacts* such as degradation due to cyclic use or exposure to unprecedented operating conditions during extreme events**
  - **Enhanced decision support methods and tools for *lifecycle evaluation* of infrastructure system outcomes**
  - **Integration of existing management and geospatial databases**

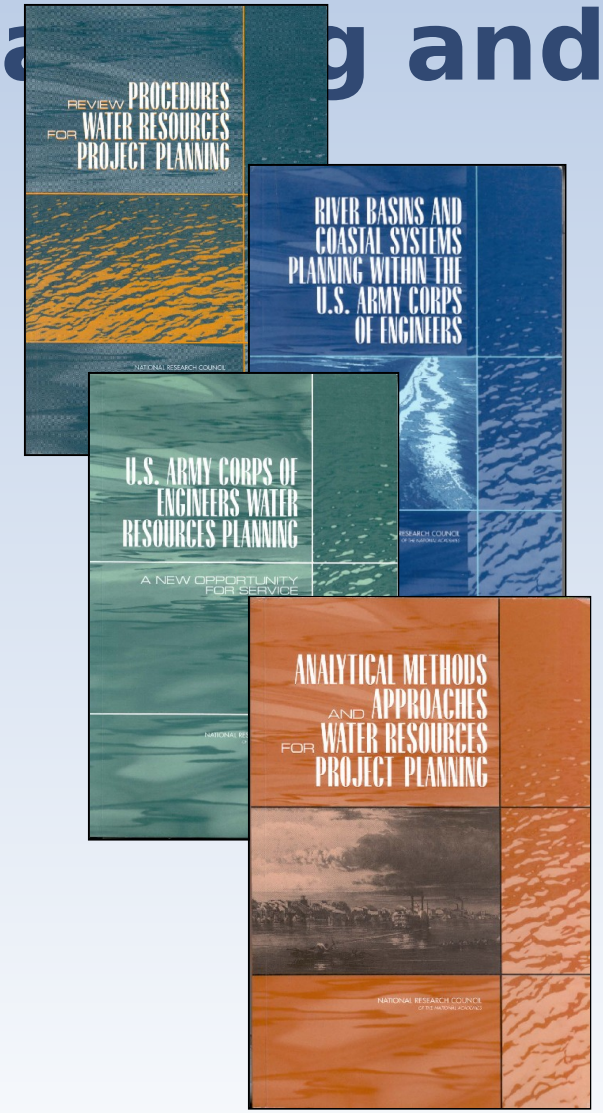
Leaking spare miter gates, Upper Miss Lock 19

Crumbling lock wall, Lower Mon 3, opened in 1907

ACTIONS for CHANGE

Multi-Objective Pla g and Policy PDT

- **Background**
  - **In 2004, the NRC recognized that the USACE planning process was unduly constrained by limitations in the decision-making framework, competing pressures by stakeholders on planners, and lack of a consistent Federal policy.**
  - **To ensure increased system-wide economic and environmental benefits, USACE must adopt an *integrated, comprehensive and systems based approach that places the highest priority on protection of public health and safety*, rather than simply national economic development (NED).**
  - **Future multi-objective decision making should have a tighter linking of risk assessment, scenario-planning, and risk-informed decision making within the overall planning framework.**


REVIEW PROCEDURES FOR WATER RESOURCES PROJECT PLANNING
RIVER BASINS AND COASTAL SYSTEMS PLANNING WITHIN THE U.S. ARMY CORPS OF ENGINEERS
U.S. ARMY CORPS OF ENGINEERS WATER RESOURCES PLANNING
A NEW OPPORTUNITY FOR SERVICE
ANALYTICAL METHODS AND APPROACHES FOR WATER RESOURCES PROJECT PLANNING

ACTIONS for CHANGE

Multi-Objective Planning and Policy PDT

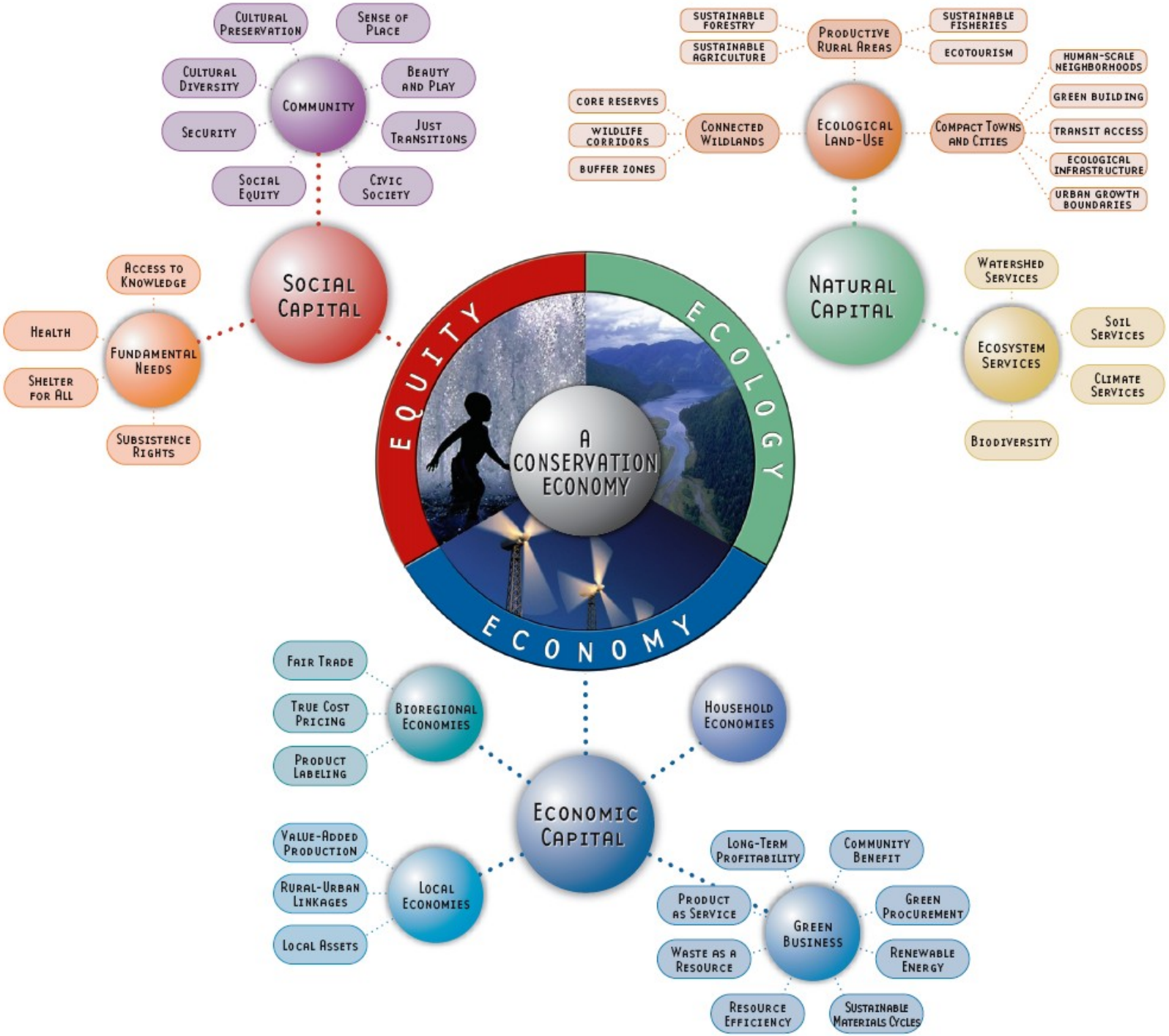
- **Objective**
  - **Develop comprehensive, adaptive, systems approaches for multipurpose planning that:**
    - **place the highest priority on protection of public health and safety**
    - **take into account natural and social system features**
    - **consider the impacts of incremental changes in the system over time**
  - **Modify plan formulation and engineering policy on alternatives analysis and cost-sharing to account for the impacts of a comprehensive systems approach, including the disproportionate unintended consequences**
- **PDT Lead**
  - **Susan Durden (IWR)**

ACTIONS for CHANGE

Multi-Objective Planning and Policy PDT

- **Expected Products and Activities**
  - **Planning and engineering tools to support *improved understanding of the system* within which a proposed system component will perform**
  - **Identify and develop system toolsets to emphasize life safety and the other social effects (OSE) account**
    - **include national ecosystem restoration (NER) and regional economic development (RED) along with NED**
    - **properly evaluate nonstructural alternatives that reduce life safety risk and provide environmental benefit**
    - **support visualization and evaluation of incremental changes over time in the watershed, region, or system**
  - **Revise policy on *cost-sharing* for planning using a comprehensive systems approach, including the disproportionate unintended consequences or additional costs due to the change from local to comprehensive system**

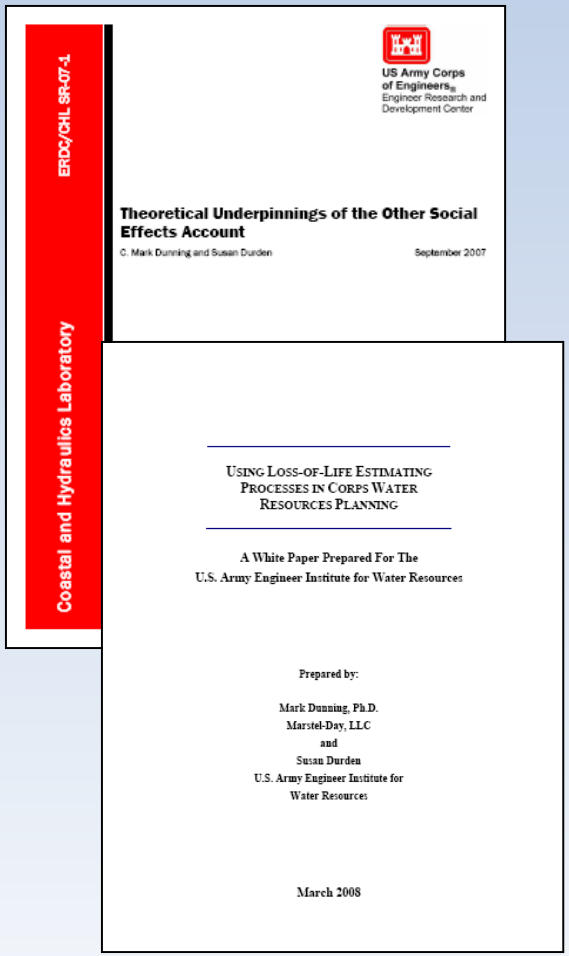
ACTIONS for CHANGE



www.ConservationEconomy.net

Planned Activities in Near Term

- **Apply the Social Vulnerability Index to a greater range of Corps projects and determine what modifications, if any, are needed to make it applicable/easy to use generally in Corps analysis**
- **Evaluate place vulnerability (physical and social in one system evaluation) and its application in the Corps**
- **Develop tool for Loss of Life incorporating social vulnerability**
- **White paper, Embracing Our Legacy--overview and examples of valuable systems studies performed in the past**

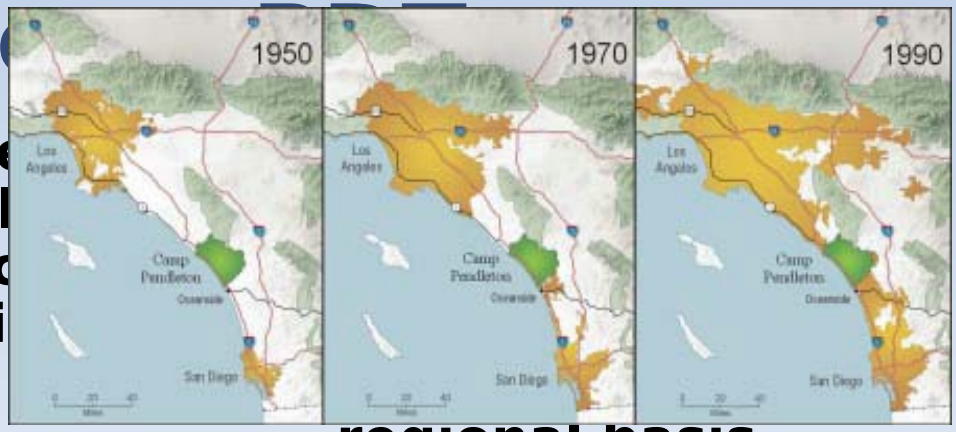

ERDC/CHL SR-07-1
Coastal and Hydraulics Laboratory
US Army Corps of Engineers
Engineer Research and Development Center
Theoretical Underpinnings of the Other Social Effects Account
C. Mark Dunning and Susan Durden
September 2007
Using Loss-of-Life Estimating Processes in Corps Water Resources Planning
A White Paper Prepared For The U.S. Army Engineer Institute for Water Resources
Prepared by:
Mark Dunning, Ph.D.
Marstel-Day, LLC
and
Susan Durden
U.S. Army Engineer Institute for Water Resources
March 2008

ACTIONS for CHANGE

Incremental Changes to USACE Systems PDT

- **Background**
  - **A comprehensive systems approach will direct the focus of making decisions *away from individual, isolated projects to the collective evaluation* of all components within an interdependent system**
  - **This approach will also require a *shift in project planning* and execution:**
    - **from local or immediate solutions to regional or long-term solutions with broader, more diverse ramifications**
    - **the inclusion of rigorous, well-documented, and disciplined analyses of the cumulative impacts of incremental changes over time**
    - **evaluations of the incremental decisions over the system life cycle to prevent an accumulation of small changes that have disproportionate, unintended consequences**

Incremental Changes to USACE Syste

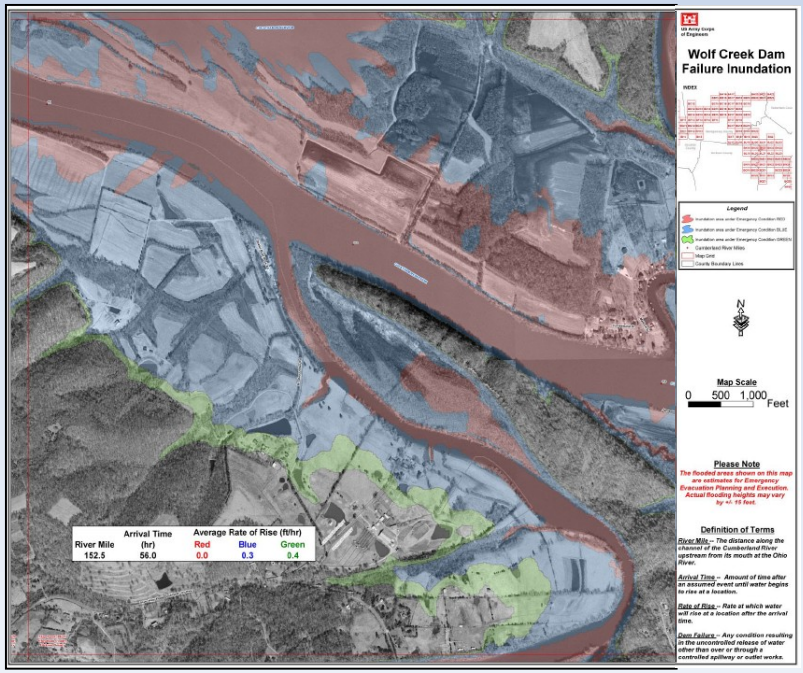


- **Objective**
  - **Support comprehensive evaluation capabil incremental c affecti regional basis**
  - **Improve USACE investment decisions by involving all the stakeholders in a comprehensive *framework that accounts for the interdependent elements and cumulative impacts within the system***
  - **Develop an approach for selecting a more adaptable plan and for sizing system features**
- **PDT Lead**
  - **Jim Westervelt (ERDC-CERL)**

ACTIONS for CHANGE

Incremental Changes to USACE Systems PDT

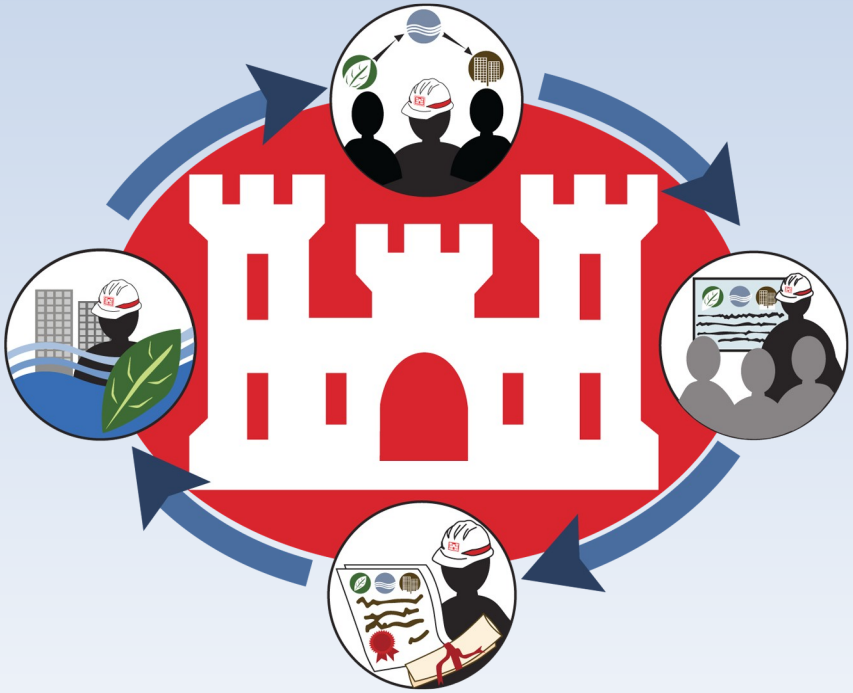
- **Expected Products and Activities**
  - **Policies and methods that support *comprehensive assessment of incremental change over time* in the watershed, region, or system**
  - **Technologies and tools assist with the visualization of incremental changes over time**



ACTIONS for CHANGE

Inundation map is a cropped version of: ftp://ftp.usace.army.mil/pub/lrn/Wolf%20Creek%20Inundation%20Maps/TN/BK21.pdf

Questions?

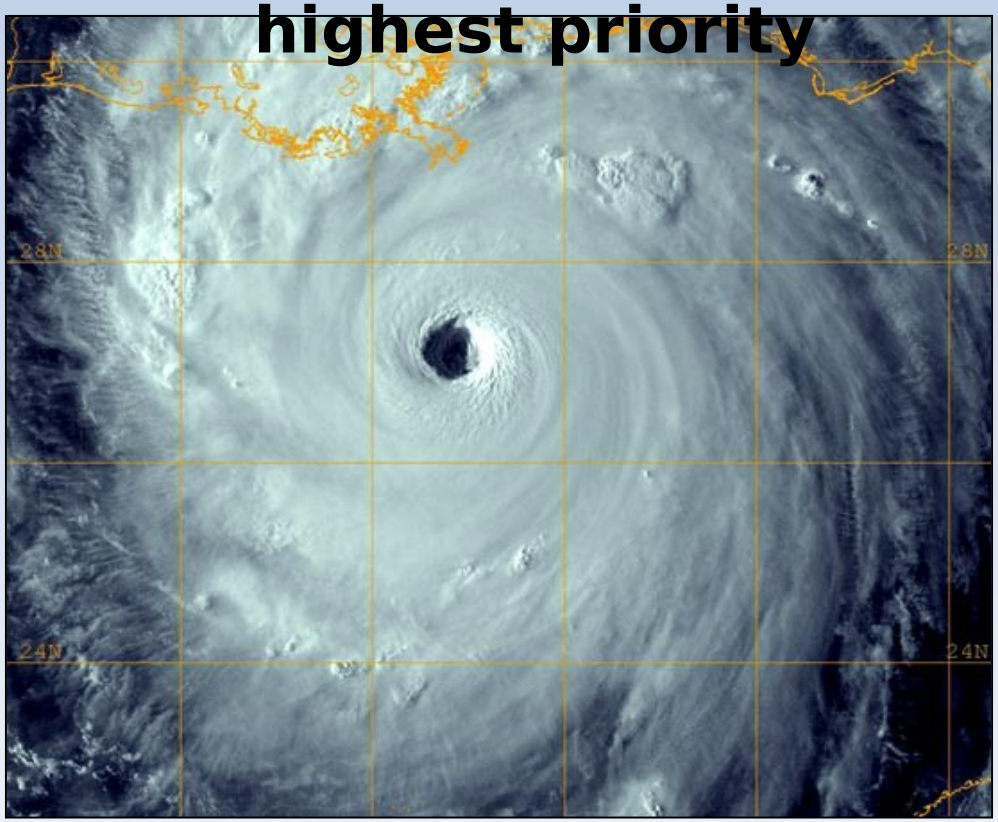


To learn more about Actions for Change
visit us on the web at
https://maps.crrel.usace.army.mil/AFC/

ACTIONS for CHANGE

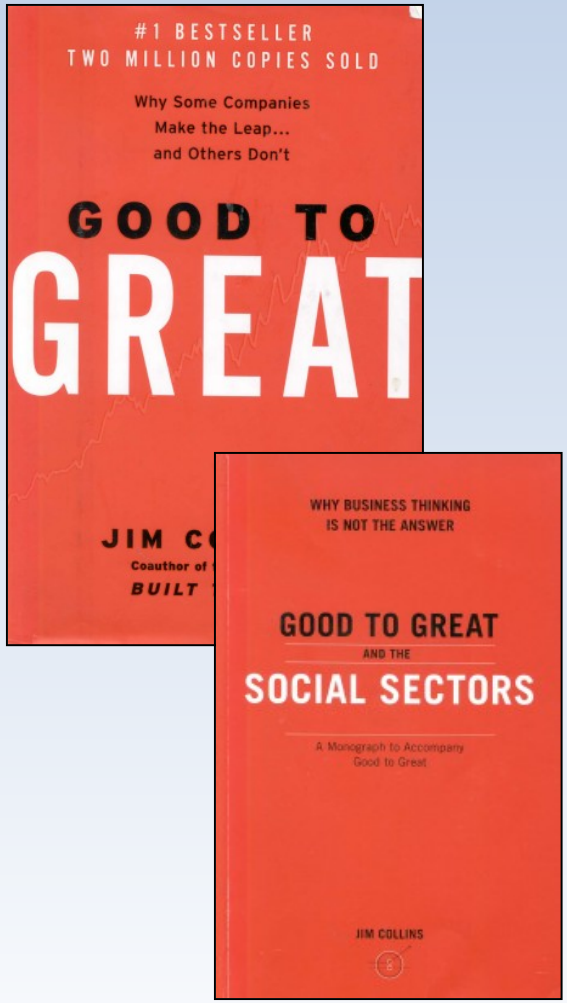
Background Slides

Deterministic, project-based, with NED as highest priority



Risk-based comprehensive system approach to integrated water resources management with public safety as highest priority

ACTIONS for CHANGE



"The fox knows many small things, the hedgehog knows one big thing."

What are we passionate about?

What drives our resource engine?

What can we be best in the world at?

- **No organization can be best in the world at everything**
- **It's not about what we <u>want</u> to be the best at, it's what we <u>can</u> be the best at**

Actions for Change
Bottom Line Up Front

"The Corps is responsible for the projects we build and manage, and we are accountable to the American people ….. for those who doubt us, words alone will not restore confidence. We are mindful that the public trust is earned when we follow through on our actions."

– Lieutenant General Carl A. Strock

ACTIONS for CHANGE

USACE Emerging Strategic Requirements

- **Broader systems approaches**
- **Consideration of interacting technical, human, organizational and social factors**
- **Risk-based decision support tools and skills**
- **Much broader coalitions and collaboration**
- **Increased public-private partnerships**
- **Anticipatory engineering**
- **Focus on sustainability**

AFC Comprehensive Systems Approach

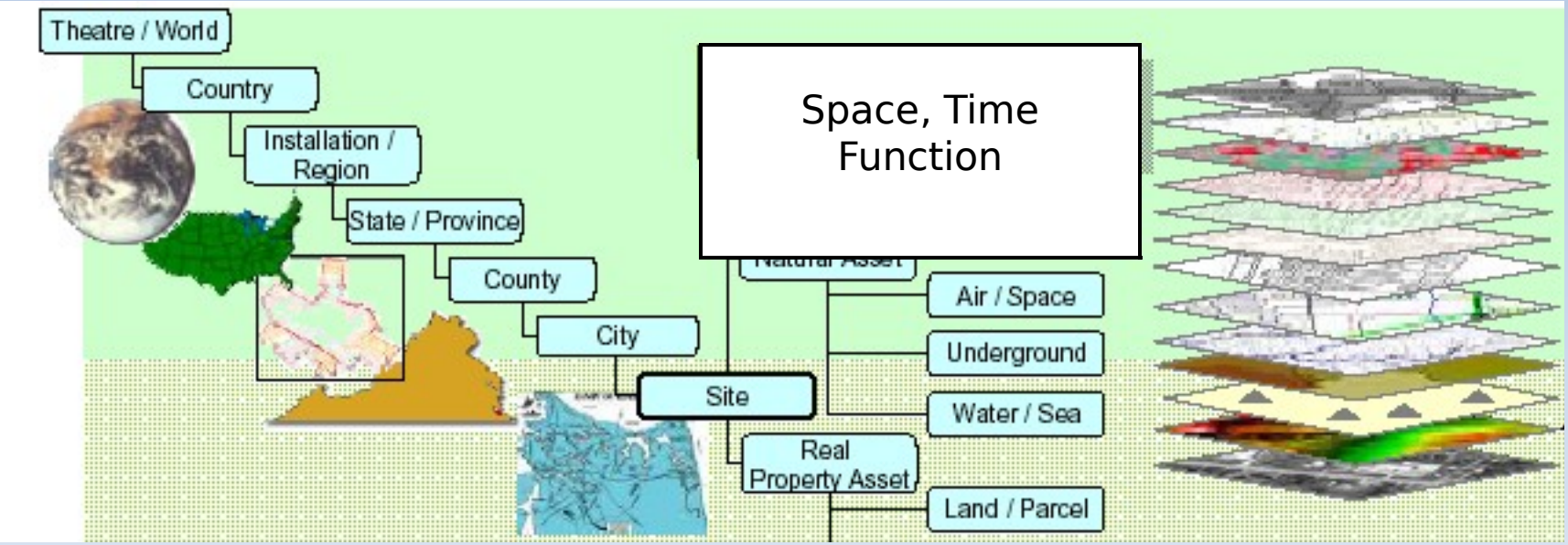
- **Consider space, function and time**
- **Implement a more holistic approach to water resources**
- **Integrate sponsors, stakeholders, Federal and State agencies**
- **Balance sustainable development and environmental protection**
- **Enhance national, regional & local partnerships**
- **Benefit from standardization and expanded use of spatial data and visualization tools**

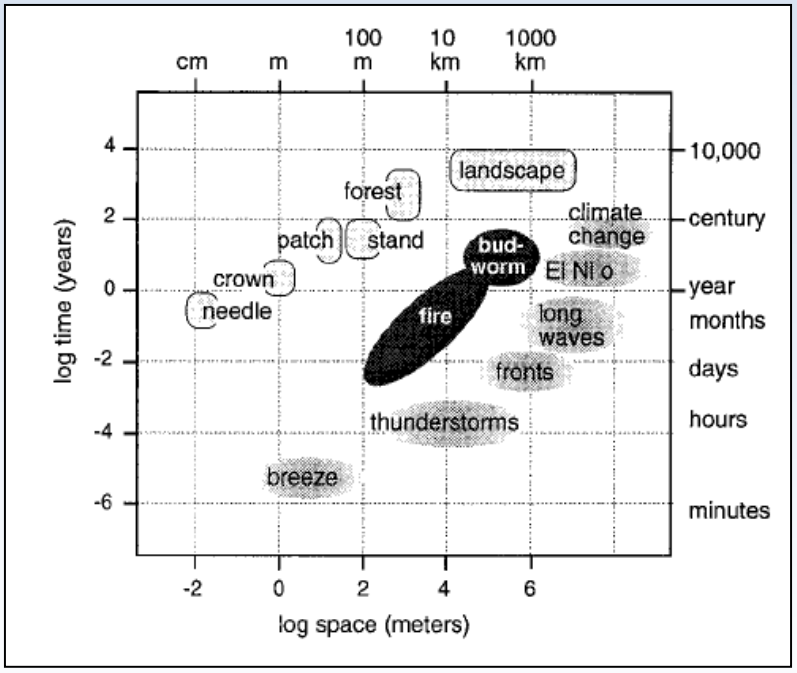
ACTIONS for CHANGE

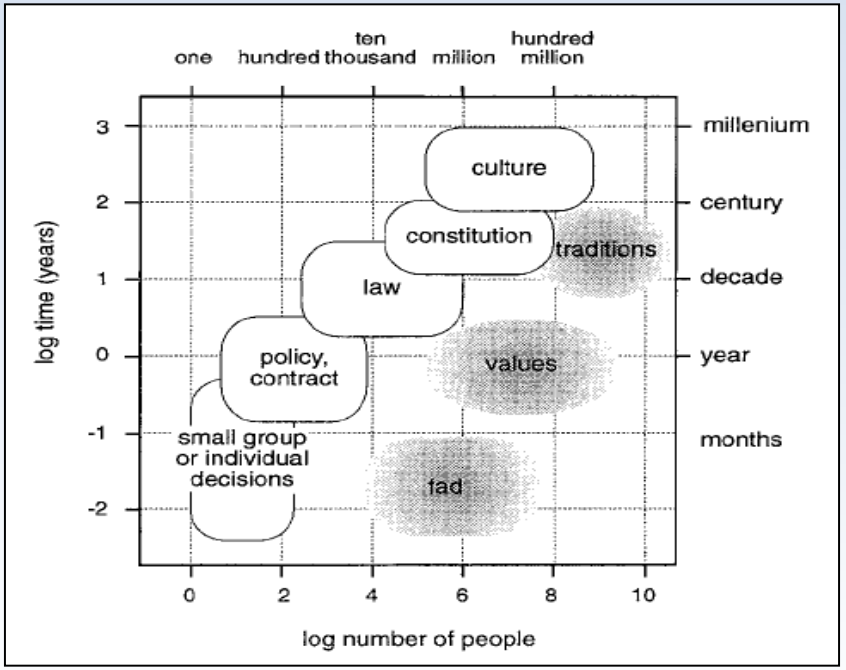
AEC Comprehensive Systems Approach Mission

- **To effect fundamental change in the US Army Corps of Engineers (USACE)**
- **Develop and implement an integrated, comprehensive and systems based approach in the execution of all its mission areas**
  - **Incorporate anticipatory management to remain adaptable and sustainable over time**
  - **Placing the highest priority on protection of public health and safety**
  - **Consistent with the Corps Environmental Operating Principles**

ACTIONS for CHANGE







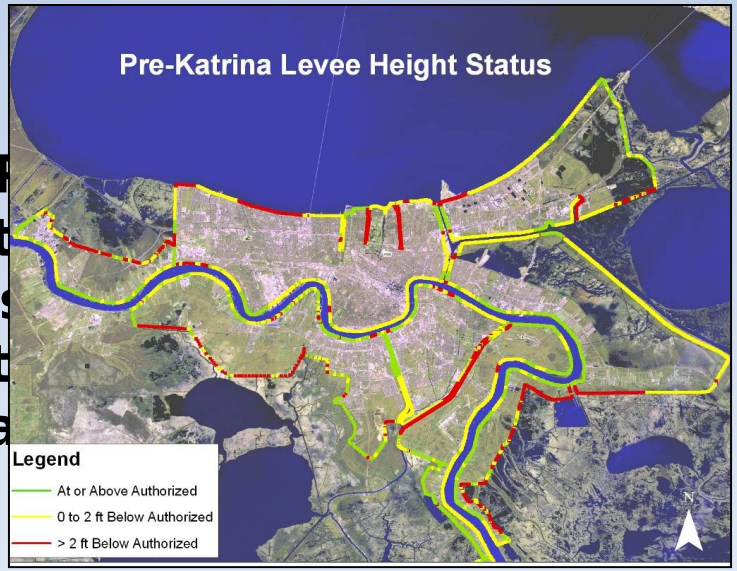
Boreal Forest

Holling 2001: Understanding the Complexity of Economic, Ecological, and Social Systems

Institutional Hierarchy of Rule S

Theme 1 - Project Delivery Teams

- **Vertical Control**
  - **"Findings of errors [from the IP Study] of one to three feet of the elevations construct and evalua and flood structures in New Orleans highlighted the need to** ensure that our flood control and navigation projects across the country are referenced to the proper vertical datums..."



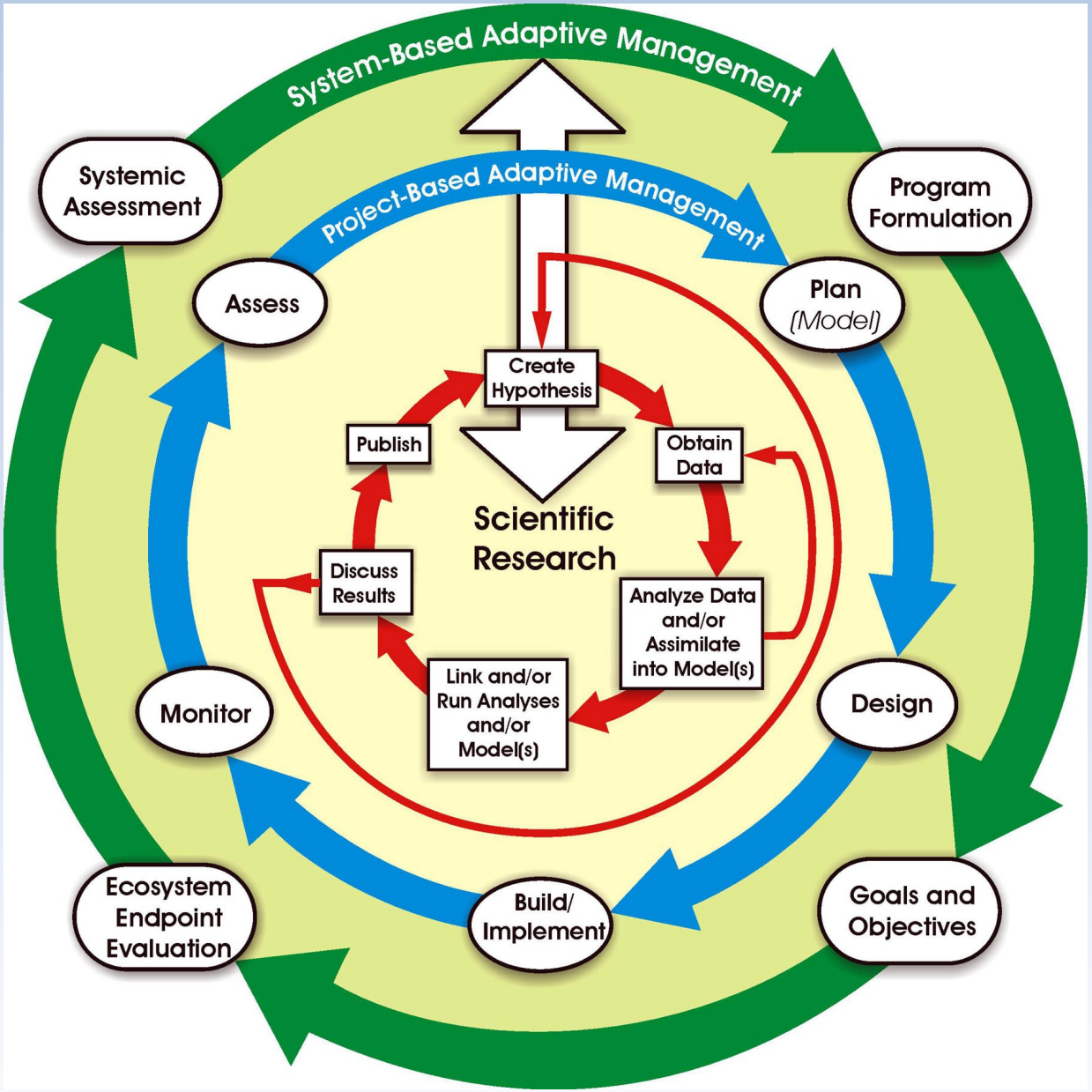
  - **Implement a nationwide datum and subsidence standard for geodetic and water level information within USACE**
  - **POC Jim Garster (ERDC-TEC)**

ACTIONS for CHANGE

Lieutenant General Carl A. Strock, Memorandum For Major Subordinate Commands, December 2006

Theme 1 - Project Delivery Teams

- **Adaptive Management**
  - **Develop a framework for adaptive management that can be incorporated into USACE Civil Works projects to allow for flexible decision making in the face of uncertainty**
  - **Result will be a business process aimed at balancing economic, social, and ecological factors for a sustainable future**
  - **POC Ken Barr (MVR)**


System-Based Adaptive Management
Project-Based Adaptive Management
Systemic Assessment
Program Formulation
Assess
Plan (Model)
Create Hypothesis
Publish
Obtain Data
Scientific Research
Discuss Results
Analyze Data and/or Assimilate into Model(s)
Link and/or Run Analyses and/or Model(s)
Monitor
Design
Ecosystem Endpoint Evaluation
Build/ Implement
Goals and Objectives

Note on Adaptive Management

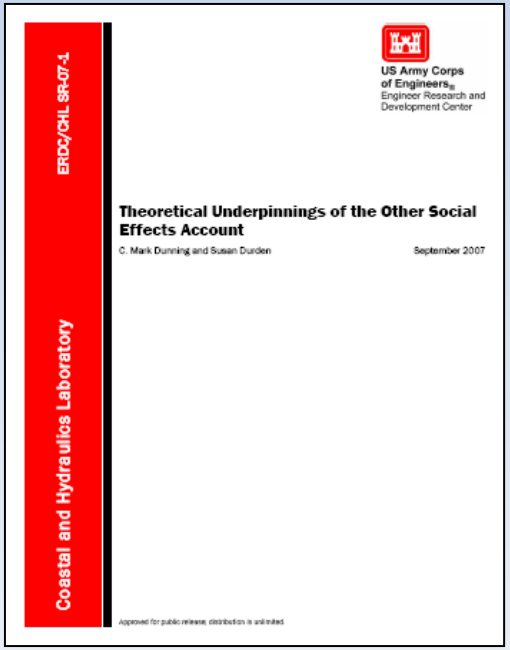
"Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. *It is not a 'trial and error' process, but rather emphasizes learning while doing.* Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits."

From DOI Technical Guide (2007) after NRC (2004), emphasis added

ACTIONS for CHANGE

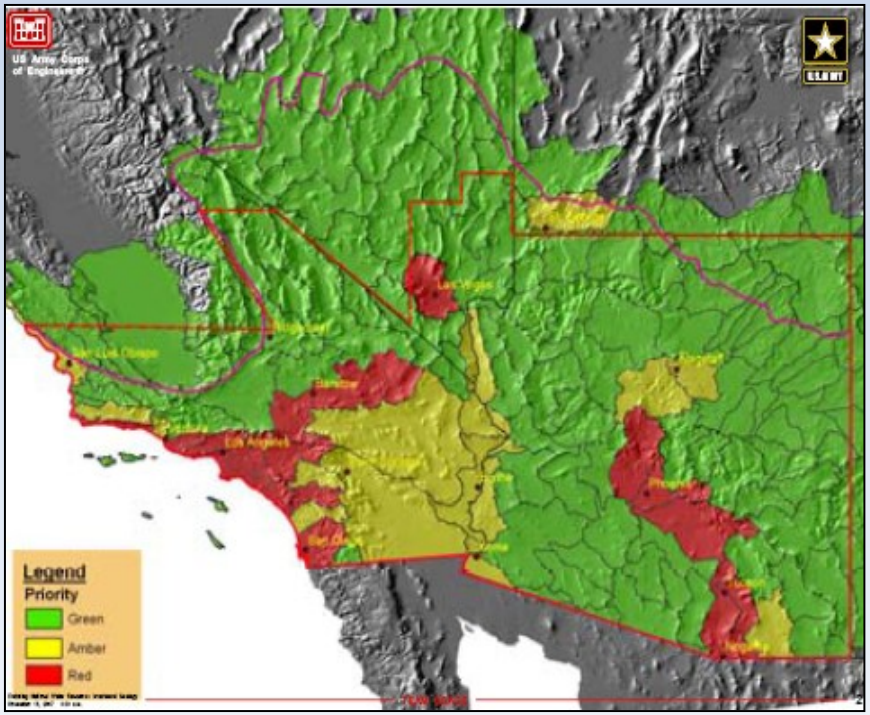
Theme 1 - Project Delivery Teams

- **Multi-Objective System Planning and Policy**
  - **Develop a comprehensive, adaptive, systems approach for multi-objective planning that places the highest priority on protection of public health and safety**
  - **Address unanticipated consequences and impacts to cost sharing**
  - **POC Susan Durden (IWR)**


ERDC/CHL SR-07-1
US Army Corps of Engineers
Engineer Research and Development Center
Theoretical Underpinnings of the Other Social Effects Account
C. Mark Dunning and Susan Durden
September 2007
Coastal and Hydraulics Laboratory
Approved for public release; distribution is unlimited.

Watershed Investment Decision Model

- **Objective**
  - **Will include all facets of comprehensive systems approach and other AFC themes**
  - **Support more effective investments while balancing competing demands**



ACTIONS for CHANGE